Short Report POSEIDON Cruise 419

Methane seepage from gas hydrate deposits offshore W-Spitsbergen:

Biogeochemical cycling and climatic relevance

Tromsø-Longyearbyen-Trondheim
10. Aug. – 07. Sept. 2011

Cruise lead
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I. Objectives

The Arctic changes rapidly in response to global warming and it is expected that this change will accelerate in the future. Large areas of the shelves and continental slopes bordering the Arctic Ocean are characterized by permafrost and the presence of gas hydrates. In the light of a warming globe and potential hydrate dissociation in the Arctic Ocean this raises concerns for a substantial additional green house gas release into the atmosphere. The recent discovery of numerous gas flares at the outcrop of the base of the gas hydrate stability zone west of Spitsbergen may be evidence that gas hydrate dissociation and accelerated methane release induced by climate change is already ongoing, and there is the possibility that such releases will accelerate global warming in the future. The expedition POSEIDON 419 aimed at understanding biological and biogeochemical processes that are connected to methane releases from melting gas hydrates. Microbial methanotrophy in the sediment and in the water column acts as a natural filter of methane releases into the atmosphere; however, it is unknown how fast and effective this filter will function in cases of massive gas hydrate melting and what the potential secondary consequences (e.g., ocean acidification and development of oxygen minimum zones) are.

More than 250 pockmarks and gas plumes have been observed and mapped at the slope of the western Svalbard margin. All these investigations were mainly geo-physically orientated, whereas investigations of the biology, species composition, biogeochemistry, geochemistry of the seep communities are nearly totally lacking. Poseidon expedition 419 was one of the first to fill this gap

Main objectives of Poseidon 419 were:

- To identify gas flares by acoustic imaging (ship´s multi-beam).
- To quantify the methane release in the water column from water samples.
- To quantify methane bubble rates with an in situ oblique multi-beam device.
- To quantify aerobic bacterial methane uptake in the water column.
- To identify cold seeps and seep fauna by photographic imaging.
- To measure anaerobic methane oxidation rates and sulfate reduction rates in seep sediments.

II. Area of investigation

The general working area between 78° N to 79°N was situated offshore the west coasts of Spitsbergen. Work focused on three localities (Fig. 1):

- The Gas Hydrate Stability Zone (GHSZ) about 15nm west of Prins Karls Foreland, with 380m water depth.
- A solitary pockmark at about 900m water depth.
- Several pockmarks along Vestnessa Ridge at about 1200m water depth.

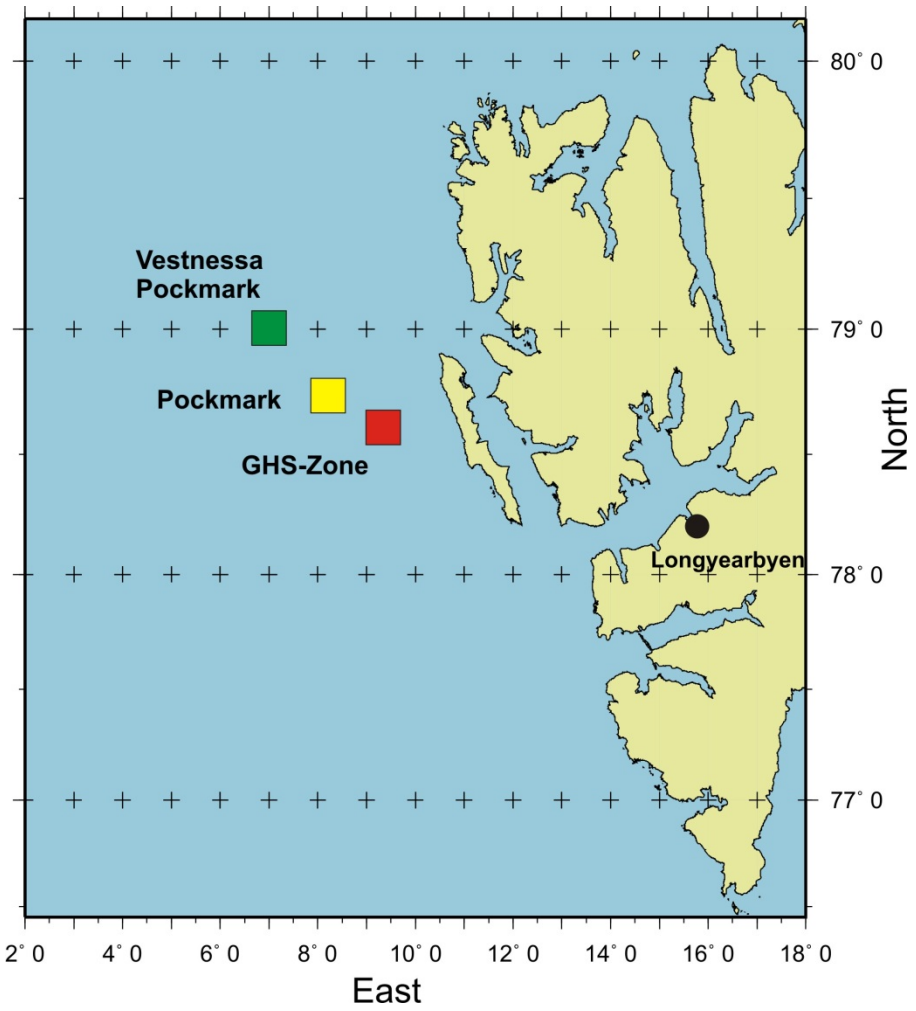

Fig. 1: Area of investigation with the three working stations.

III. Participants

	Name	Occupation	Institution
1.	Pfannkuche, Olaf	Scientist	IFM-GEOMAR
2.	Bertics, Vicki	Scientist	IFM-GEOMAR
3.	Bussmann, Ingeborg	Scientist	AWI
4.	Greinert, Jens	Scientist	NIOZ (until 27. 8)
	Sztybor, Kamila	Scientist	Univ. Tromsø (from 27. 8.)
5.	Herzig, Peter	Observer	IFM-GEOMAR (until 15. 8.)
6.	Hommer, Julia	Technician	IFM-GEOMAR
7.	Kretschmer, Kerstin	Student	IFM-GEOMAR
8.	Schott,Thorsten	Technician	Oktopus
9.	Sommer, Stefan	Scientist	IFM-GEOMAR (until 30.08)
10.	Treude, Tina	Scientist	IFM-GEOMAR (until 30.8.)
11.	Türk, Mathias.	Electronic engineer	IFM-GEOMAR
12.	Veloso, Mario	Scientist	Univ. Gent

IV. Participating Institutions

AWI: Alfred-Wegener-Institut für Polar- und Meeresforschung, Biologische Anstalt Helgoland, Kurpromenade 201, 27498 Helgoland, Germany.

IFM-GEOMAR: : Leibniz-Institut für Meereswissenschaften, Wischhofstr. 1-3, 24148 Kiel, Germany.

NIOZ: Koninklijk Nederlands Instituut voor Zeeonderzoek, Landsdiep 4, 1797 SZ 't Horntje (Texel), Netherlands.

Oktopus: OKTOPUS GmbH, Department Kiel, Wischhofstraße 1-3, 24148 Kiel, Germany.

Univ. Gent: Renard Centre of Marine Geology, Krijgslaan 281 S8, Gent, Belgium

Univ. Tromsø: Department of Geology**,** University of Tromsø**,** Dramsveien 201**,** N-9037 Tromsø**,** Norway.

V. Narrative of the cruise

Wednesday, 10-08-2011: R/V POSEIDON left the harbor of Tromsø at noon starting its 419th journey with a group of 12 scientists from the institutes: IFM-GEOMAR, AWI (Germany), NIOZ (Netherlands) and Univ. of Gent (Belgium). The ship was bound to the region west of Spitsbergen. The first working area was at 78° 35,10´N / 09° 27,40´E off Prins Karls Forland.

Thursday, 11-08-2011: We continued our passage to the working area through the Barents Sea.

Friday, 12-08-2011: We continued our passage to the workings area through the Greenland Sea.

Saturday, 13-08-2011: We reached our first working site at 78° 35,10´N / 09° 27,40´ E and started station work with a CTD/Rosette water sampler (CTD/RO) cast by 380m water depth (Stat. 595) at the border of the gas hydrate stability zone (GHSZ) where numerous gas flares could be detected with the multi-beam in the water column. We then changed to photographic sea floor observation running three profile lines with the Ocean Floor Observation System (OFOS) taking films and digital photo shots in 1,5m distance from the sea floor (Stat. 596-98). Afterwards we made another CTD/RO cast (Stat. 599). During the night we drove several parallel survey lines with the multi-beam (Elac Nautic 3050) to map gas flares along the border of the gas hydrate stability zone (Stat. 600).

Sunday, 14-08-2011: After the multi-beam survey we steamed in down slope direction to a solitary pock mark structure by 920m water depth where we made a CTD/RO cast (Stat. 601). Afterwards three OFOS profile lines were driven through the pockmark (Stat. 602-04). After another CTD/RO cast (Stat. 605) we changed position and started with a series of three CTD/RO cast by 834m 637m and 546m (Stat. 606-08) on a slope transect line which had been already investigated by previous expeditions to this area. During the night we steamed into the Kongsfjord to Ny Alesund.

Monday, 15-08-2011: We arrived at Ny Alesund at 08:00h and disembarked one scientist to fly out from Ny Alesund to Germany. Scientists and members of the crew took the opportunity to visit the village. The scientists got a guided tour by the leader of the

AWI/PEV station through some laboratory buildings and to the Harbour Laboratory. We left Ny Alesund around 13:00h and after a short visit to the glacier at the fjord end we steamed back to our working area where we drove further multi-beam gas flare detection profiles during the rest of the day and the night (Stat. 609).

Tuesday, 16-08-2011: The multi-beam survey ended during the morning, afterwards we deployed a lander (GasQuant) carrying an oblique multi-beam system, near to a lander deployed from the British vessel James Clark Ross some days before, to measure the temporal and spatial variability of gas bubbles (Stat. 610) for two days. After the GasQuant deployment we left the area and steamed to Vestnessa Ridge in 79° 00, 70´ N / 06° 53,1´ E where we drove an OFOS profile through a pock mark (Stat. 611) and made a CTD/RO cast (Stat. 612) by ca. 1230m depth.

Wednesday, 17-08-2011: A first multicorer (MUC) sediment sample at the Vestnessa pockmark (Stat. 613) failed since the on-line TV-camera monitoring the instrument´s operation did not work. We then steamed back to the GHSZ off Prins Karls Foreland where we deployed the Biogeochemical Observatory Lander (BIGO, Stat. 614). A CTD/RO cast at the BIGO-deployment site followed (Stat. 615). We then steamed back to the CTD/RO-slope transect which was started on Sunday to make two further CTD/RO casts by 460m and 430m (Stat. 616-17). The night was spent with gas flare detection along several multi-beam track lines in the gas hydrate stability zone (Stat. 618).

Thursday, 18-08-2011: During the morning we shortened the coaxial cable on our mobile winch by 2500m to gain a better video signal for the OFOS, TV-MUC and the deployment frame for the lander systems. In the afternoon we retrieved the GasQuant lander deployed on Aug 16 (Stat. 619). Afterwards we changed position to Vestnessa Ridge where we made two unsuccessful MUC casts (Stat. 620-21). Due to the high waves the gear dipped on the sea floor and released the closing devices of the sampling tubes preventing a sample. During the night we steamed back to the GHSZ.

Friday, 19-08-2011: Our first action at the GHSZ was the retrieval of the BIGO Lander deployed on Aug. 17 (Stat. 622). We then turned to OFOS survey at the GHSZ (Stat. 623). Afterwards we steamed to Vestnessa Ridge. We started with a multi-beam survey of a pockmark to map the localities of gas flares (Stat. 624). A CTD/RO cast in this pockmark followed (Stat 625). During the night we inspected 10 pockmarks along the Vestnessa Ridge with short multi-beam profiles to search for gas flares. In total we identified 3 pockmarks with gas flares (Stat. 626).

Saturday, 20-08-2011: We started in the morning with sediment sampling with the MUC in one of the pockmarks (Stat. 627). Again we were not able to take a sample since the high waves prevented a sampling by closing the sampling lids prematurely in the water column. We decided to finish our activities at Vestnessa and steamed back to calmer waters at the GHSZ where we deployed the GasQuant lander (Stat. 628). The day ended with two more CTD/Ro cast by 410m and 370m on the shelf/slope transect (Stat. 629-30)

Sunday, 21-08-2011: The day started with the first successful MUC sample in one of the Vestnessa Pockmarks (Stat. 631). Two OFOS survey lines to identify chemosynthetic based benthic communities (Pogonophora, bacterial mats) where driven in the same pockmark (Stat. 632-33). We then returned to the GHSZ to deploy a BIGO Lander next to the GasQuant deployment site (Stat. 634). Two more CTD/RO cast were driven afterwards on the shelf-slope transect (Stat. 635-336). During the night we returned to Vestnessa Ridge.

Monday, 22-08-2011: The day started with a MUC sample of a seep site in one of the pockmarks where we found well developed gas flares (Stat. 637). Afterwards we returned to the GHSZ station and started with a 24h-CTD/RO survey of the gas flare site where the

GasQuant and BIGO lander were deployed. In combination with a 75kHz ship bound ADCP survey water samples were taken in 1.5h intervals until the next day (Stat. 638-54).

Tuesday, 23-08-2011: The 24h-CTD/RO survey ended in the afternoon. With retrieval of the GasQuant (Stat. 655) and the BIGO (Stat. 656) we finished the highly resolved survey of this site. We then turned back to Vestnessa Ridge where we started with another multi-beam survey to identify gas flares (Stat. 657). This survey had to be cancelled after one hour because the high waves impacted the acoustics.

Wednesday, 24-08-2011: The day started with a MUC sample of a bacterial mat at a seep site (Stat. 658). Afterwards we drove an OFOS survey line across the sampled seep (Stat. 659). We then steamed back to the GHSZ where we deployed the GasQuant next to a gas flare (Stat. 660). During the whole night we drove two multi-beam survey tracks from the deployment site about 25nm to the north along the 380m depth contour to identify new gas flare sites along the border of the gas hydrate stability zone (Stat. 661).

Thursday, 25-08-2011: Station work started in the morning with the deployment of the BIGO very near to the GasQuant deployment site from the previous day (Stat. 662). We then changed position again to Vestnessa where we started with a MUC cast (Stat. 663) followed by two OFOS survey profiles crossing the MUC sampling site (Stat. 664-65). During the night we returned to the GHSZ site.

Friday, 26-08-2011: We started the day with two CTD/RO casts by 387m and 232m (Stat. 666-67). This action was followed by the retrieval of the GasQuant deployed on the 24.08. (Stat. 668) Afterwards we left the working area and steamed to Longyearbyen to disembark one scientist from NIOZ who was substituted by a scientist from the University of Tromsø. We lay at anchor in Longyearbyen from 22:00h to 02:30h next day. Tranfers were made with the rescue boat.

Saturday, 27-08-2011: We returned during the night and morning to the GHSZ Station and retrieved the BIGO deployed on the 25.08. (Stat. 669). Afterwards we drove an OFOS profile crossing all previous landers deployment sites (Stat. 670). Afterwards we made 3 CTD/RO casts in the same area (Stat. 671-73). During the night we steamed to Vestnessa Ridge.

Sunday, 28-08-2011: We started in the morning with a MUC deployment in the methane seep area (Stat. 674). Unfortunately the cable caught one leg of the MUC and the gear returned upside down with no samples. During the course of the day we made two more successful MUC casts (675-76). The day ended with a multi-beam profile across several depressions at Vestnessa Ridge to seek for gas flares (Stat. 677).

Monday, 29-08-2011: The day started with a MUC sample in seep area (Stat. 678). We managed to sample the center of bacterial mat covering about $10m^2$ of the sea floor.. The sampled sediments also contained gas hydrates and small carbonates. Afterwards we returned to the GHSZ site where we took 4 CTD/RO samples between 232m and 268m (Stat. 679-82). In the early evening we abandoned station work and steamed again to Longyearbyen to disembark two scientists from IFM-GEOMAR.

Tuesday, 30-08-2011: We arrived at Longyearbyen at noon and disembarked the two scientists with the rescue boat. Afterwards we left immediately and returned to the GHSZ area where we made 5 CTD/RO casts at two localities (Stat, 683-87).

Wednesday, 31-08-2011: During the night we changed position to Vestnessa Ridge. We started with a MUC sample and a gravity corer cast on the outer Ridge (Stat. 688-89). Then we returned to the pockmark where our main activities were centered the days before and took two more gravity corer samples (Stat. 690-91). With this action station work of POSEIDON cruise 419 ended. At 14:00h we started our journey to Trondheim.

Thursday, 01-09-2011: We continued our passage to Trondheim through the Greenland Sea.

Friday, 02-09-2011: We continued our passage to Trondheim through the Greenland Sea.

Saturday, 03-09-2011: We continued our passage to Trondheim through the Norwegian Sea.

Sunday, 04-09-2011: We continued our passage to Trondheim through the Norwegian Sea.

Monday, 05-09-2011: We continued our passage to Trondheim through the Norwegian Sea.

Tuesday, 06-09-2011: We arrived at Trondheim harbor at 18:15h

Wednesday, 07-09-2011: With the unloading of the ship in the morning cruise POSEIDON 419 ended.

VI. Equipment used and gear abbreviations

- Gas flare imaging with multi-beam (**MB**).
- CTD and Rosette water sampler (**CTD/RO**).
- Sea floor imaging with Ocean Floor observation System (**OFOS**).
- Surficial sediment sampling with TV-multicorer (**MUC**).
- Long sediment core sampling with gravity corer (**GC**).
- Sediment-Water Interface Gas sampling with Biogeochemical Observatory (**BIGO**).
- In situ acoustic gas bubble quantification with Lander (**GasQuant**).

VII. List of sampling Stations

See over leaf

Gear	No.	Date	Time	Coordi	nates 1	Depth	Coordi	nates 2	Depth	Time
		2011	(UTC)	Lat. °N	Long. °E	(m)	Lat. °N	Long. °E	(m)	(UTC)
CTD/RO	1	13.08.	11:08	78° 35,108	09° 27,414	389				
OFOS	1	13.08.	16:03	78° 35,387	09° 26,027	392	78° 35,000	09° 28,010	377	17:40
OFOS	2	13.08.	18:50	78° 35,171	09° 26,093	399	78° 34,908	09° 28,036	377	19:17
OFOS	3	13.08.	20:24	78° 35,234	09° 27,570	379	78° 34,961	09° 27,604	388	20:58
CTD/RO	2	13.08.	21:32	78° 35,107	09° 27,475	387				
MB	1	13.08.	22:21	78° 35,340	09° 27,260	382				
CTD/RO	3	14.08.	06:01	78° 41,354	08° 15,739	920				
OFOS	4	14.08.	07:35	78° 41,617	08° 14,487	907	78° 41,037	08° 16,099	895	08:53
OFOS	5	14.08.	11:05	78° 40,830	08° 12,568	917	78° 40,448	08° 15,541	903	12:14
OFOS	6	14.08.	13:45	78° 40,701	08° 14,499	923	78° 40,437	08° 14,827	922	15:29
CTD/RO	4	14.08.	15:15	78° 40,579	08° 14,536	931				
CTD/RO	5	14.08.	17:23	78° 37,660	08° 34,780	834				
CTD/RO	6	14.08.	18:45	78° 37,886	08° 52,657	637				
CTD/RO	7	14.08.	20:15	78° 38,224	09° 04,166	546				
MB	2	15.08.	20:13	78° 39,800	09° 25,910	284				
GasQuant Depl	1	16.08.	13:05	78° 33,236	09° 28,603	394				
OFOS	7	16.08.	19:40	79° 00,704	06° 53,146	1236	79° 00,371	06° 55,336	1234	20:47
CTD/RO	8	16.08.	21:51	79° 00,421	06° 54,230	1233				
MUC	1	17.08.	10:01	79° 00,479	06° 54,150	1233				
BIGO Depl	1	17.08.	16:38	78° 35,109	09° 27,401	387				
CTD/RO	9	17.08.	17:10	78° 35,110	09° 27,380	380				
CTD/RO	10	17.08.	18:36	78° 38,470	09° 11,900	460				
CTD/RO	11	17.08.	19:34	78° 38,730	09° 17,290	430				
MB	3	17.08.	20:34	78° 38,150	09° 26,510	*401*				
GasQuant Retr	1	18.08.	13:03							
MUC	2	18.08.	17:29	79° 00,439	06° 54,331	1243				

MUC	3	18.08.	21:45	79° 00,470	06° 54,030	1232				
BIGO Retr	1	19.08.	06:14							
OFOS	8	19.08.	08:14	78° 35,166	09° 27,395	380	78° 35,135	09° 27,231	388	09:23
MB	4	19.08.	14:26	79° 00,070	06° 53,850	1230				
CTD/RO	12	19.08.	17:44	79° 00,460	06° 53,880	1229				
MB	5	19.08.	19:47	78° 59, 335	07° 00,373	1200				
MUC	4	20.08.	08:30	79° 00,370	06° 54,067	1229				
GasQuant Depl	2	20.08.	20:16	78° 35,081	09° 27,473	386				
CTD/RO	13	20.08.	22:13	78° 38,911	09° 20,556	410				
CTD/RO	14	20.08.	21:21	78° 38,970	09° 22,300	380				
MUC	5	21.08.	07:05	79° 00,483	06° 53,999	1231				
OFOS	9	21.08.	08:47	79° 00,713	06° 53,682	1234	79° 00,210	06° 54,090	1230	09:47
OFOS	10	21.08.	11:46	79° 00,641	06° 54,049	1236	79° 00,735	06° 53,914	00:00	12:53
BIGO Depl	2	21.08.	19:22	78° 35,107	09° 27,408	386				
CTD/RO	15	21.08.	20:36	78° 39,230	09° 39,150	173				
CTD/RO	16	21.08.	21:06	78° 39,040	09° 32,860	200				
MUC	6	22.08.	07:30	79° 00,419	06° 54,440	1236				
CTD/RO	17	22.08.	13:45	78° 35,090	09° 27,455	387				
CTD/RO	18	22.08.	15:10	78° 35,313	09° 27,313	388				
CTD/RO	19	22.08.	16:44	78° 35,108	09° 27,277	388				
CTD/RO	20	22.08.	18:14	78° 35,110	09° 27,350	388				
CTD/RO	21	22.08.	19:44	78° 35,110	09° 27,291	388				
CTD/RO	22	22.08.	21:13	78° 35,109	09° 27,294	388				
CTD/RO	23	22.08.	22:45	78° 35,127	09° 27,319	388				
CTD/RO	24	23.08.	00:13	78° 35,110	09° 27,291	388				
CTD/RO	25	23.08.	01:43	78° 35,108	09° 27,296	388				
CTD/RO	26	23.08.	03:14	78° 35,108	09° 27,306	388				
CTD/RO	27	23.08.	04:44	78° 35,114	09° 27,296	388				

CTD/RO	28	23.08.	06:13	78° 35,106	09° 27,291	388				
CTD/RO	29	23.08.	07:43	78° 35,113	09° 27,328	388				
CTD/RO	30	23.08.	09:14	78° 35,110	09° 27,292	388				
CTD/RO	31	23.08.	10:43	78° 35,114	09° 27,323	388				
CTD/RO	32	23.08.	12:12	78° 35,115	09° 27,350	388				
CTD/RO	33	23.08.	13:44	78° 35,120	09° 27,190	388				
GasQuant Retr	2	23.08.	14:30							
BIGO Retr	2	23.08.	17:00							
MB	6	23.08.	22:08	79° 59,890	06° 57,707	1206				
MUC	7	24.08.	07:48	79° 00,415	06° 54,229	1204				
OFOS	11	24.08.	09:11	79° 00,378	06° 54,091	1231	79° 00,378	06° 53,821	1234	10:30
GasQuant Depl	3	24.08.	19:10	78° 35,053	09° 27,412	388				
MB	7	24.08.	19:39	78° 34,748	09° 27,738	381				
BIGO Depl.	3	25.08.	08:58	78° 35,089	09° 27,378	388				
MUC	8	25.08.	16:19	79° 00,600	06° 54,094	1204				
OFOS	12	25.08.	18:13	79° 00,495	06° 53,575	1230	79° 00,406	06° 54,730	1229	18:41
OFOS	13	25.08.	20:01	79° 00,390	06° 53,688	1226	79° 00,572	06° 55,072	1234	20:48
CTD/RO	34	26.08.	05:58	78° 39,070	09° 21,660	387				
CTD/RO	35	26.08.	06:44	78° 39,060	09° 27,870	232				
GasQuant Retr	3	26.08.	07:45							
BIGO Retr.	3	27.08.	12:00							
OFOS	14	27.08.	13:02	78° 35,910	09° 27,284	385	78° 34,902	09° 26,00	14:05	00:00
CTD/RO	36	27.08.	14:35	78° 35,080	09° 27,360	390				
CTD/RO	37	27.08.	16:02	78° 35,144	09° 29,178	350				
CTD/RO	38	27.08.	17:00	78° 35,190	09° 32,180	280				
MUC	9	28.08.	10:36	79° 00,400	06° 53,640	1236				
MUC	10	28.08.	15:31	79° 00,466	06° 54,279	1241				
MUC	11	28.08.	17:33	78° 59,774	06° 58,064	1191				

MB	8	28.08.	18:18	78° 59,999	06° 56,800	1223				
MUC	12	29.08.	07:47	79° 00,417	06° 54,131	1235				
CTD/RO	39	29.08.	12:52	78° 39,080	09° 29,850	232				
CTD/RO	40	29.08.	13:28	78° 39,060	09° 27,920	236				
CTD/RO	41	29.08.	13:59	78° 39,050	09° 25,970	244				
CTD/RO	42	29.08.	14:41	78° 39,003	09° 24, 438	268				
CTD/RO	43	30.08.	19:54	78° 28,800	09° 31,030	433				
CTD/RO	44	30.08.	20:35	78° 28,800	09° 36,460	400				
CTD/RO	45	30.08.	21:16	78° 28,960	09° 41,640	283				
CTD/RO	46	30.08.	22:32	78° 35,010	09° 22,740	430				
CTD/RO	47	30.08.	23:12	78° 35,070	09° 25,740	400				
MUC	13	31.08.	06:36	79° 08,051	05° 36,111	1325				
GC	1	31.08.	07:40	79° 08,064	05° 36,144	1326				
GC	2	31.08.	10:39	79° 00,412	06° 54,089	1233				
GC	3	31.08.	11:39	78° 59,794	06° 58,019	1223				